AWIDS Experiment

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Operator Performance Lab
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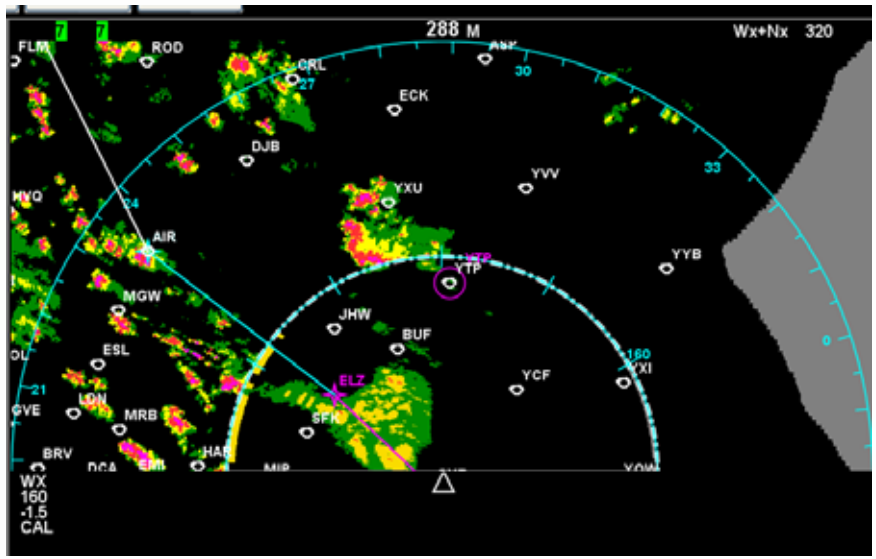
Goal of study: evaluate integrated display format

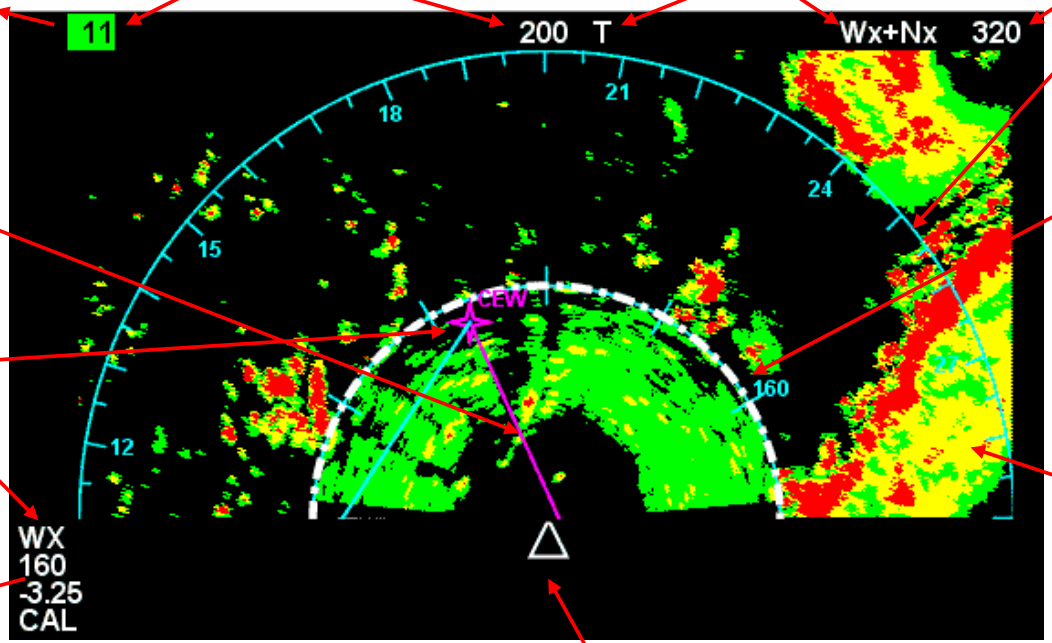
- Measure pilot weather avoidance and decision making performance using:
  - Separate WXR (navigation display) plus North-up NEXRAD (multifunction display)

    vs
  - Integrated track-up WXR/NEXRAD AWIDS display.



Integrated display format

Age of NEXRAD	Color	Example
0 – 17 minutes old	Green	11
18 – 36 minutes old	Yellow	25
37 minutes +	Red	40
No Data	Red	N/A



7 Age of NEXRAD

8 Current Track Readout

9 Track Reference (T–True; M–Magnetic)

10 Display Mode (Wx; Nx; Wx + Nx)

11 Range Setting

12 Compass Rose

13 Range Ring

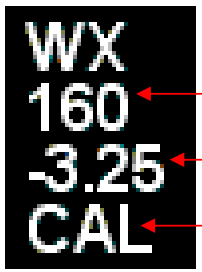
14 Weather Representation

15 Ownship Symbol

16 Weather Radar Settings

17 Waypoint

18 Flight Plan Course Line



Wx Range (NM)

Tilt (degrees)

Calibration Gain

Decision making

- **Goal 1 (G1): Determine if an integrated display positively affects the quality of decision making**
  - Good decision:
    - safe distance from storm cells
    - minimizes the rerouting distance
- **Goal 2 (G2): Determine if an integrated display enables earlier decision times**
- **Goal 3 (G3): Determine what weather display settings pilots prefer**
- **Goal 4 (G4): Determine the usability of the integrated display**

WXR simulation - Camber

Layer 1: 9000 - 16,000 ft
Layer 2: 16,000- 28,000 ft
Layer 3: 28,000 - 41,000 ft
Layer 4: 41,000 - 57,000 ft

Weather Database
Storm position, intensity

Flight Simulator
Aircraft position, altitude

Weather Panel
Tilt, Gain

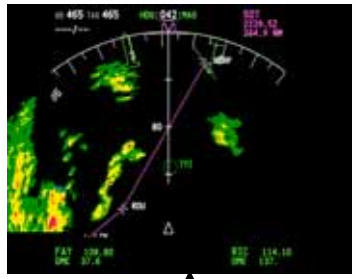
Camber
Weather Model

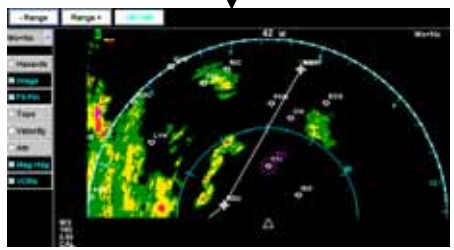
ARINC 453

Mosaic NEXRAD Database

Weather Server

Nav Display





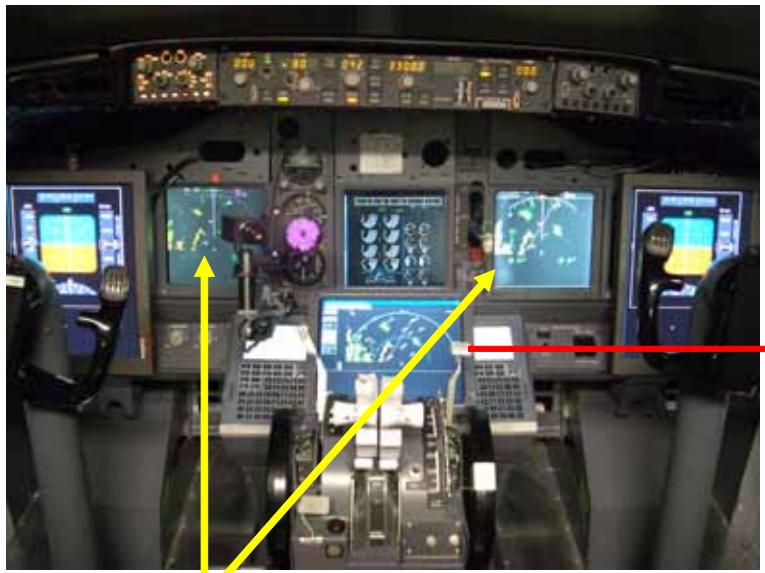
AWIDS Display

WXR simulation enabled pilots to “fly” anywhere in database region

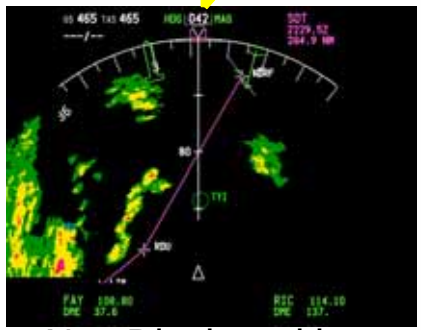
Baseline condition – Nx + WXR

Baseline Condition

Only North Up NEXRAD available



North Up
NEXRAD Only

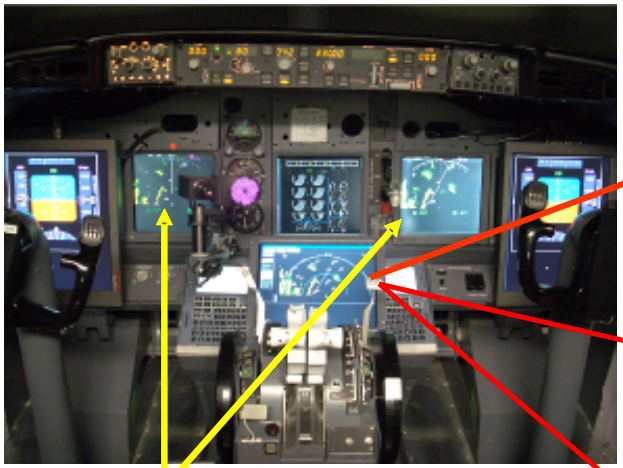


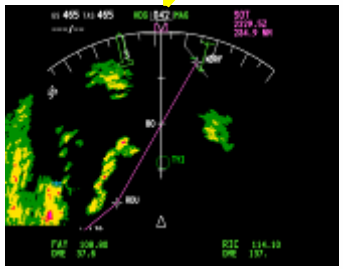
Nav Display with
Weather Radar

Experimental condition - all modes

Experimental Condition

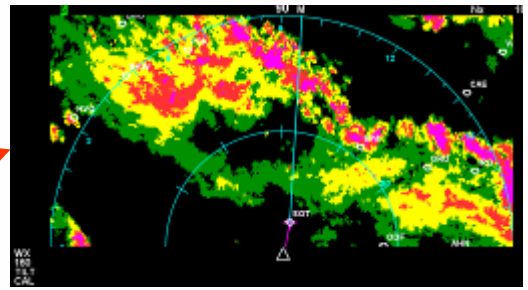
All display modes available



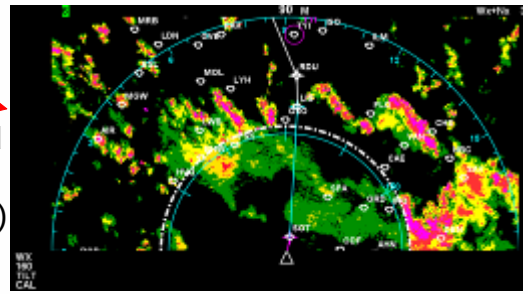


Nav Display with Weather Radar

Track Up NEXRAD



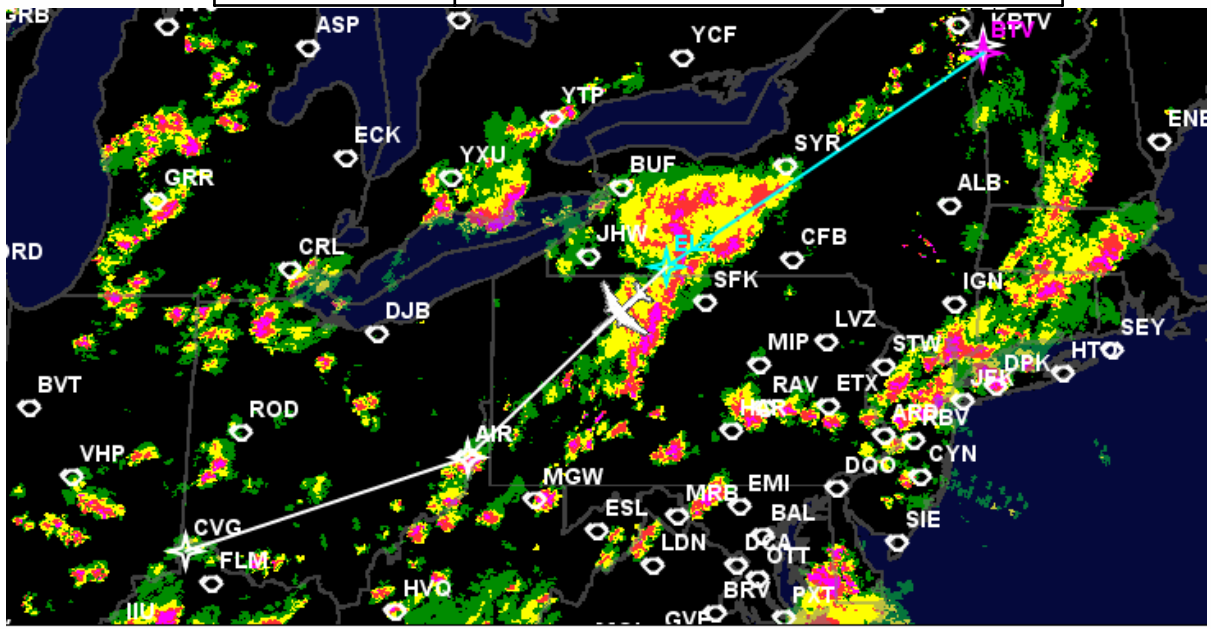
Integrated Display (Wx + Nx)



North Up NEXRAD

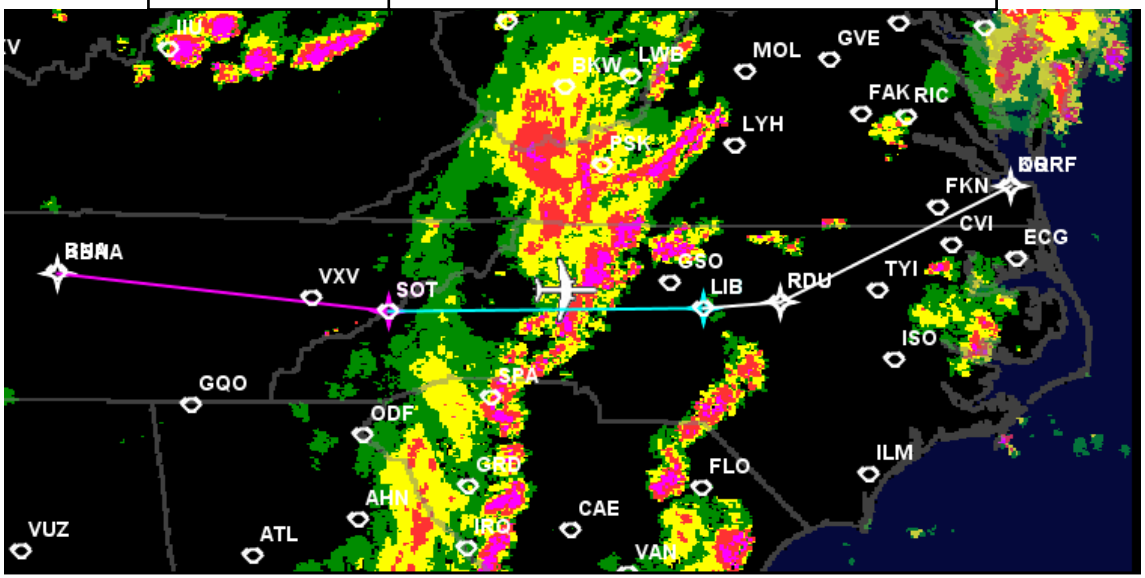
North route: KBTV - KCVG

	Flight Plan 1: 'North Route'
Departure Airport	Burlington, VT (KBTV) Burlington International Airport
Destination Airport	Covington, Kentucky (KCVG) Cincinnati/Northern Kentucky International Airport
Route	KBTV, SYR, ELZ, AIR, KCVG



South route: KBNA -> KORF

	Flight Plan 2: 'South Route'
Departure Airport	Nashville, Tennessee (KBNA) Nashville International Airport
Destination Airport	Norfolk, Virginia (KORF) Norfolk International Airport
Route	KBNA, SOT, LIB, RDW, KORF



Experimental matrix

#	First Run	Second Run
1	North Route Baseline Configuration	South Route Experimental Configuration
2	North Route Experimental Configuration	South Route Baseline Configuration
3	South Route Baseline Configuration	North Route Experimental Configuration
4	South Route Experimental Configuration	North Route Baseline Configuration

Experimental design: 2 x 2 within subjects repeated measures

Decision quality conflicting constraints

Constraint Set 1:

- ***Storm Avoidance***
  - Lateral Loss (LL)

    Lateral Storm Separation
    - ***More is better***
  - Vertical Loss (VL)

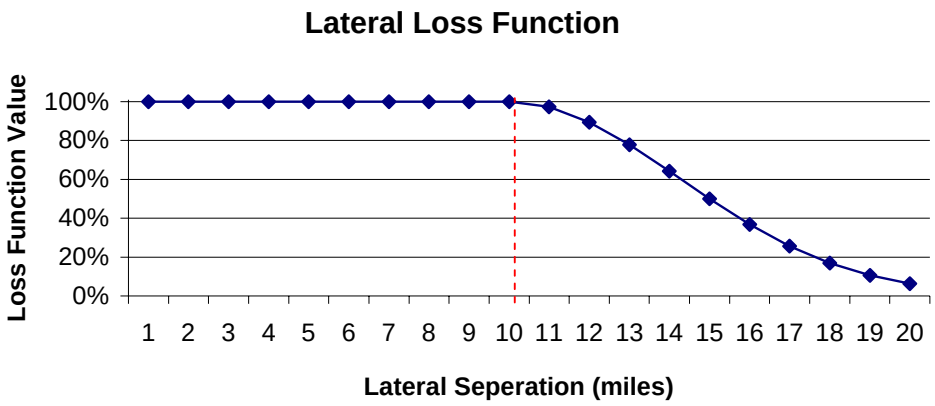
    Vertical Storm Separation
    - ***More is better***

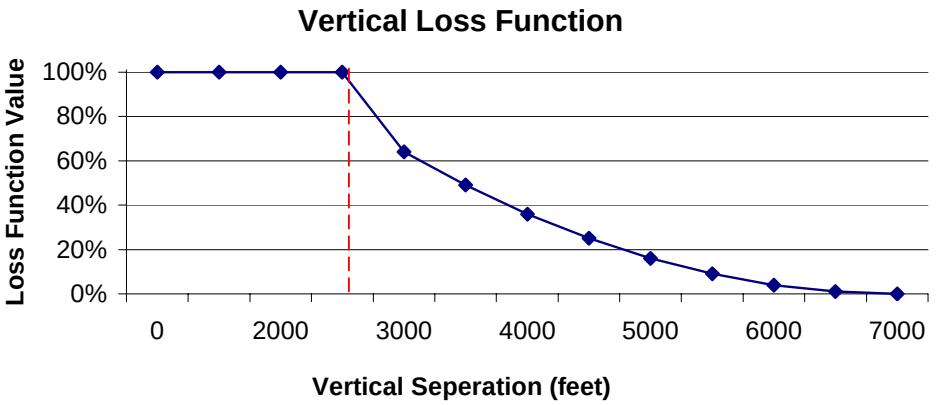
Constraint Set 2:

- ***Minimize Rerouting***
  - Distance Loss (DL)

    Additional distance traveled versus planned flight
    - ***Less is better***
  - Time Loss (TL)
  - *Increase in flight length versus planned flight*
    - ***Less is better***

Loss Function - a Taguchi Robust Design





Quadratic function describes how effectively goals—distance to storm and reroute distance—have been achieved.

Loss fn for distance not shown

Hypotheses

Hypothesis1 (H1):

- *Integrated displays result in better decisions*
- H0: MOEINTEGRATED = MOESEPARATE
- H1: MOEINTEGRATED > MOESEPARATE

Hypothesis2 (H2):

- *Integrated displays result in earlier decisions*
- H0: MOEINTEGRATED = MOESEPARATE
- H1: MOEINTEGRATED > MOESEPARATE

Hypothesis3 (H3):

- *Integrated displays result in reduced workload versus separate displays*
- H0: WORKLOADINTEGRATED = WORKLOADSEPERATE
- H1: WORKLOADINTEGRATED < WORKLOADSEPARATE

Hypothesis 4 (H4):

- *Integrated display increase weather situation awareness*
- H0: SAINTEGRATED = SASEPERATE
- H1: SAINTEGRATED > SASEPERATE

Subject Pilot Demographics

Pilot #	Wx Experience	% Hours in Wxr Equipped Aircraft	Years of Wxr Experience	NEXRAD Experience
1	yes	100%	25	yes
2	yes	100%	33	yes
3	yes	70%	1	yes
4	yes	90%	33	no
5	yes	90%	2	no
6	yes	99%	32	yes
7	yes	100%	20	no
8	yes	100%	40	no
9	yes	90%	2	no
11	yes	90%	14	yes
12	yes	95%	10	no
13	yes	90%	20	no
Mean	Y: 100%	93%	19.3	Y: 42%
St Dev	N: 0%	0.09	13.6	N: 58%
Max		100%	40.0	
Min		70%	1.0	

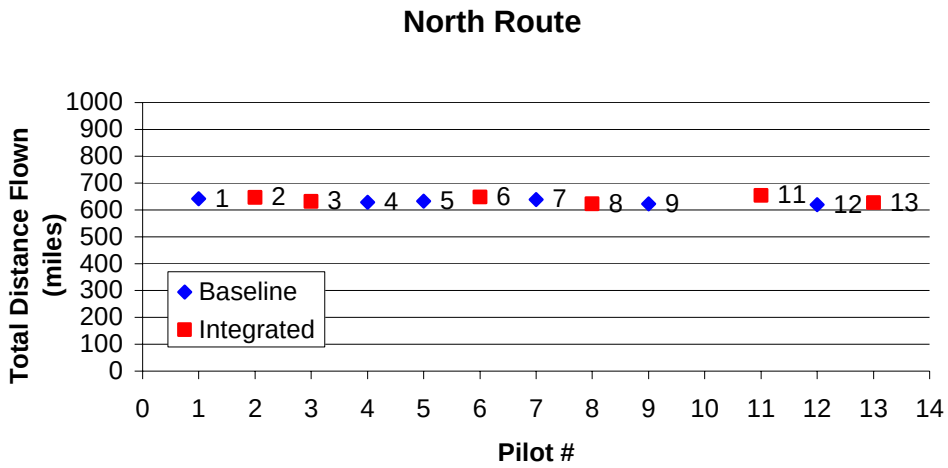
Experiment Procedure

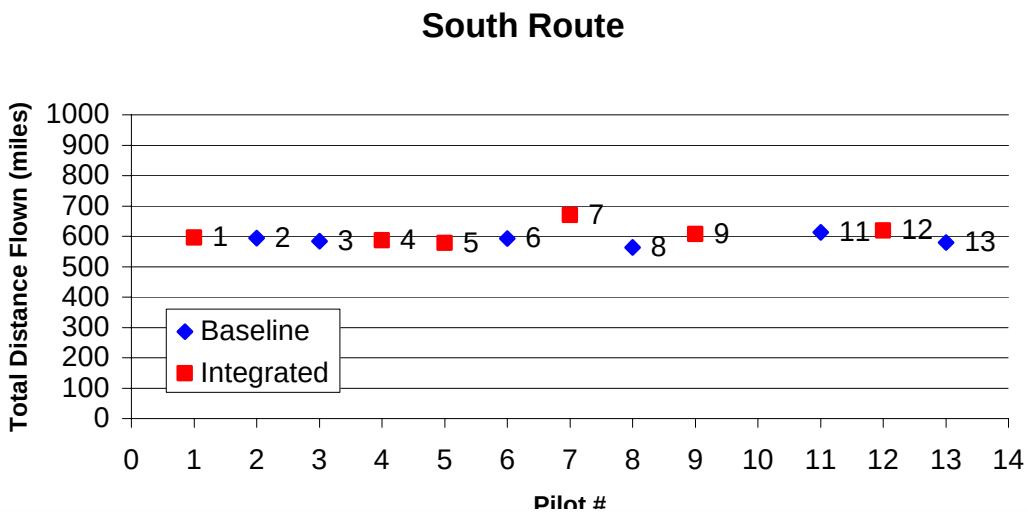
- Preliminary
- On Arrival
  - Pre-flight questionnaire
- Training
  - Guide to experimental display, short flight in NE
- Preflight Briefing
  - METARS, TAFS, c-SIGMETS, NEXRAD loop
- Flight
  - Baseline & experimental run, data logging
- Post Flight Questionnaire

Results

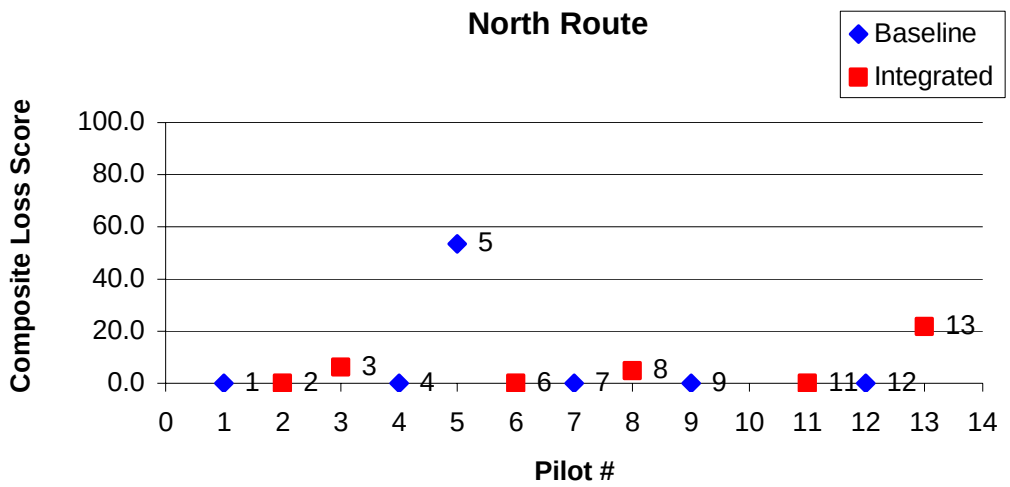
- ***Total Distance Flown***
  - The total distance flown by each pilot (**MOE3**)
- ***Lateral and Vertical Loss***
  - The results of the lateral and vertical loss function (**MOE1**, **MOE2, MOE4**)
- ***Decision Quality***
  - Assignment of ‘good’ or ‘poor’ grade on each pilot’s course based on the criteria of weather avoidance experts
- ***Time/Distance to First Deviation***
  - The time and distance a pilot traveled before executing the first deviation decision **(MOE5)**
- ***ATC Interaction, Pilot Reports and Replans***
  - The frequency of interaction with ATC (**MOE6**), the correctness of PIREPS (**MOE7**), and number of flight replans (**MOE8**)
- ***Pre & Post-Flight Questionnaire***

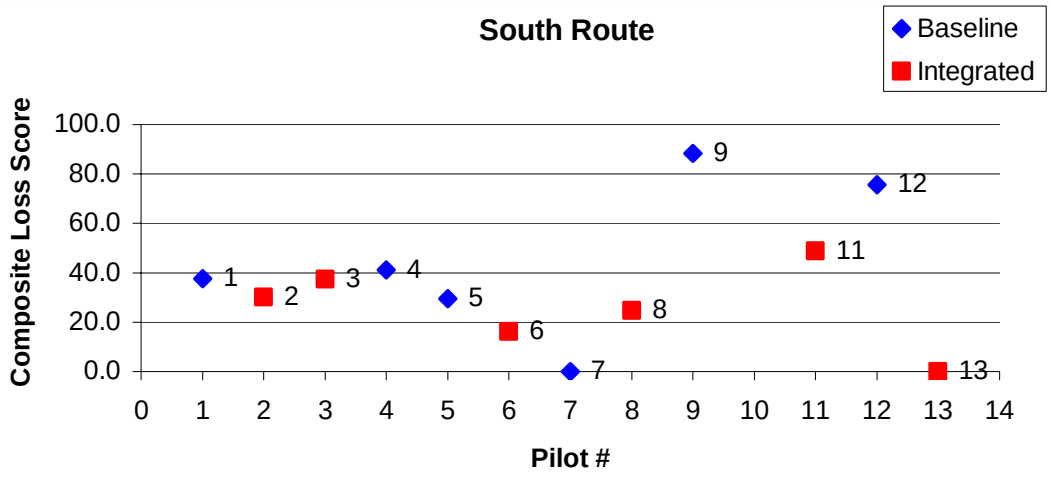
Distance flown



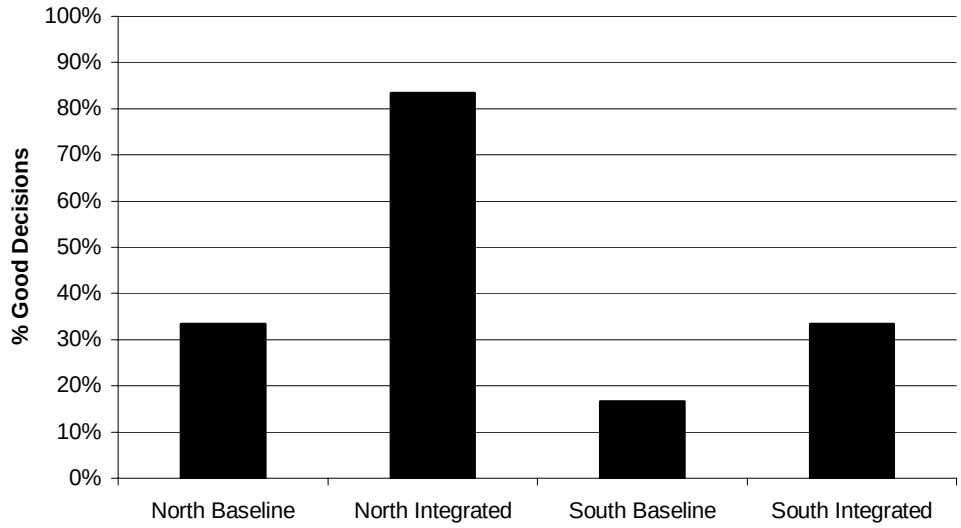


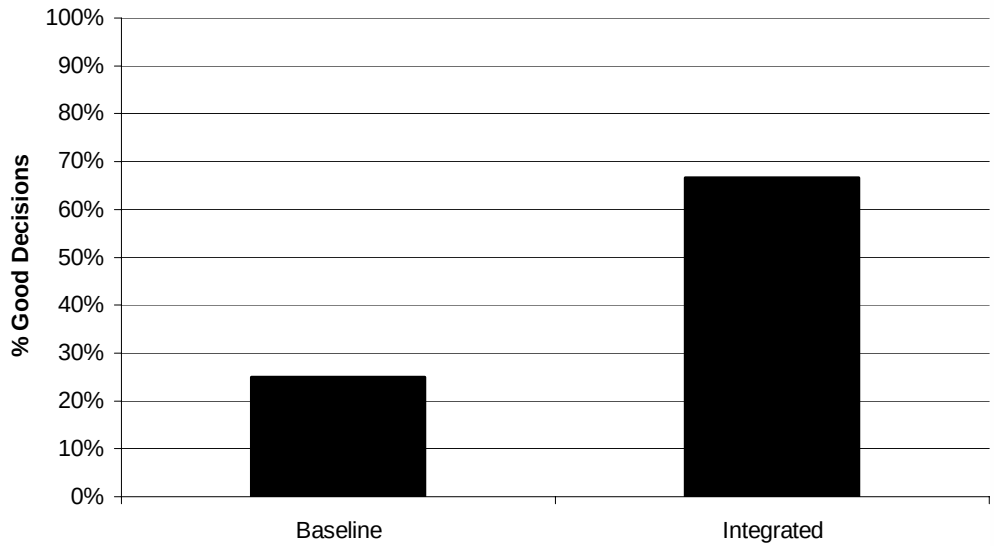
Composite vertical + lateral loss



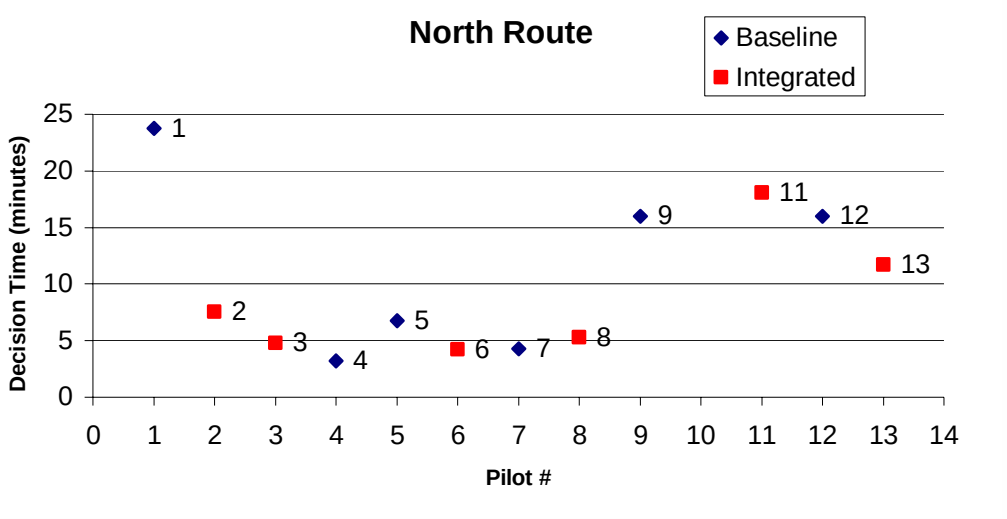


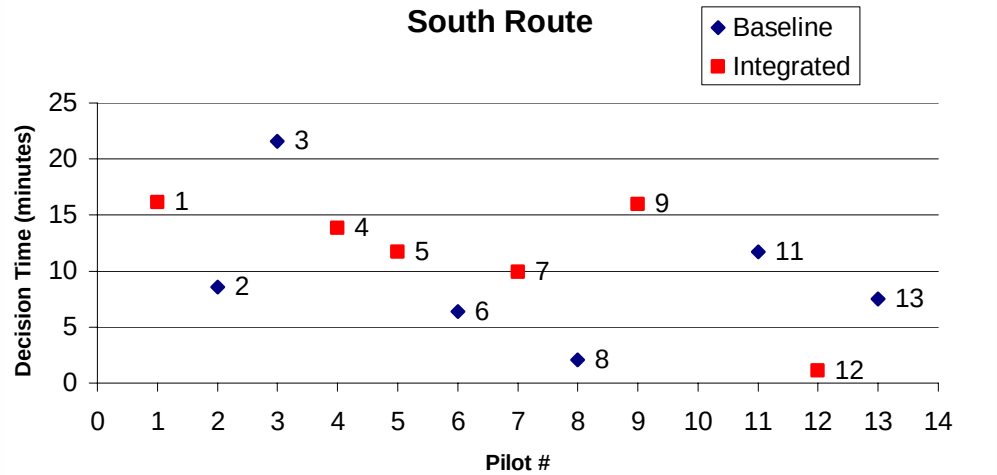
Quality of decision



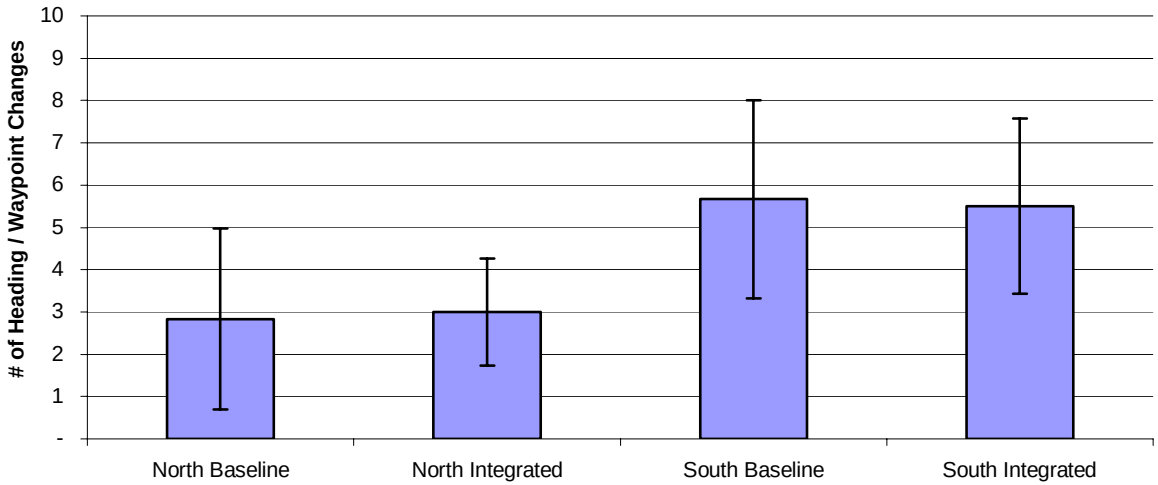


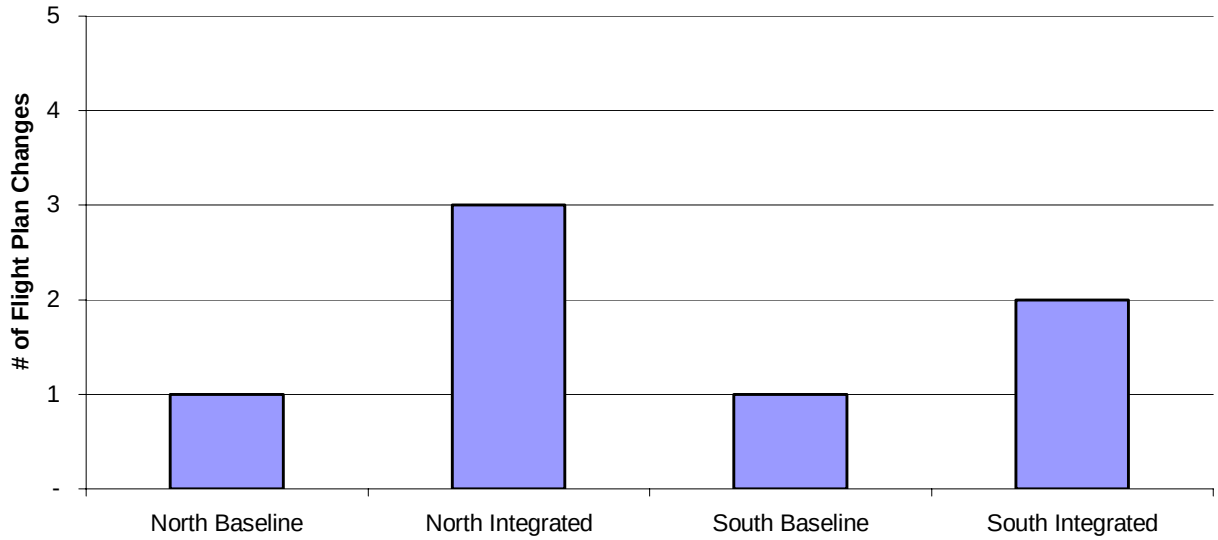
Time to deviation decision



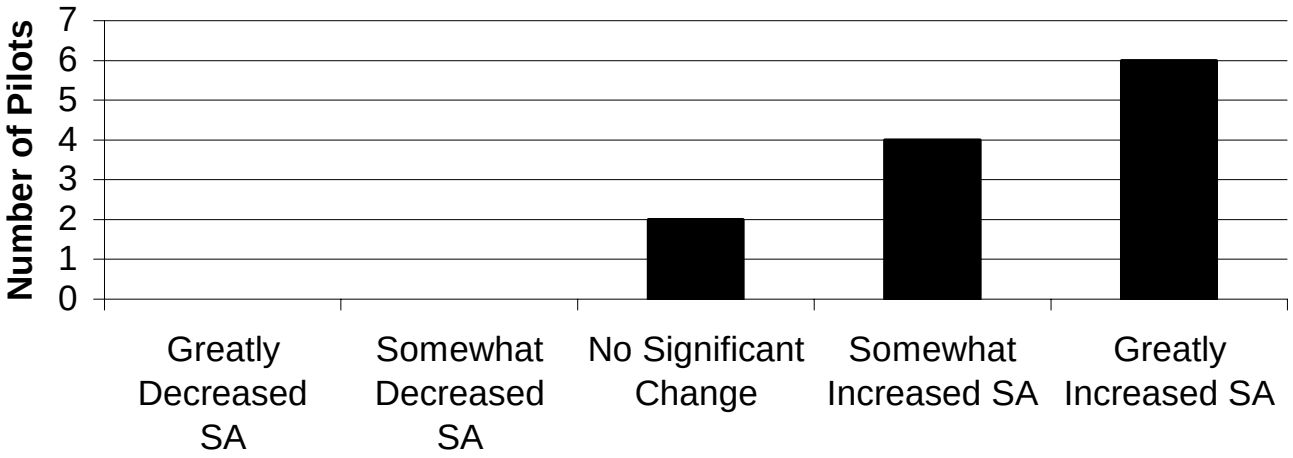


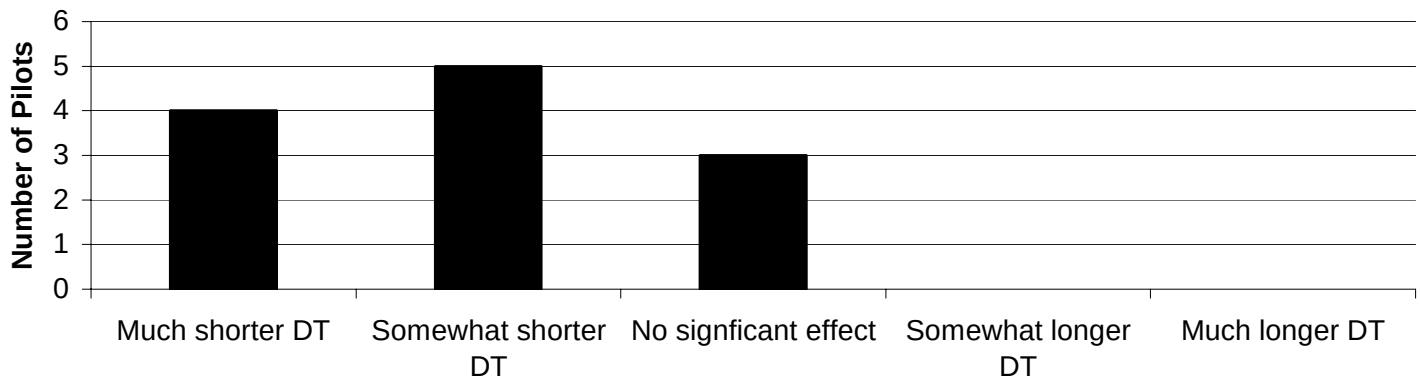
No. & type of deviations





Subjective data





Conclusions

- Decision time/distance clearly did not provide any meaningful feedback during this experiment
  - An integrated display may not elicit faster deviation
    - Affected by pilot operational habits
    - Time spent adjusting eye tracker systems
    - Deviation time occurs after pilot formulates broad plan
- The decision quality suggests that an integrated display may aid pilot in making better (safer) weather avoidance decisions
  - Decision quality far outweighs decision time